AD

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : D04H 1/70 | A1 | (11) International Publication Number: WO 97/36035

(43) International Publication Date: 2 October 1997 (02.10.97)

(21) International Application Number: PCT/EP97/01490

(22) International Filing Date: 24 March 1997 (24.03.97)

(30) Priority Data:
768/96 25 March 1996 (25.03.96) CH
2167/96 2 September 1996 (02.09.96) CH
2169/96 2 September 1996 (02.09.96) CH

(71) Applicant *(for all designated States except CH US)*: ROCKWOOL INTERNATIONAL A/S [DK/DK]; Hovedgaden 584, DK-2640 Hedehusene (DK).

(71) Applicant *(for CH only)*: FLUMROC AG [CH/CH]; Industriestrasse, CH-8890 Flums (CH).

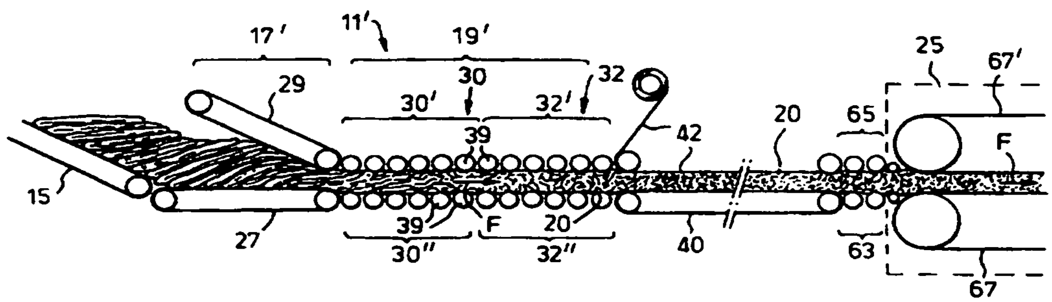
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: WYSS, Peter [CH/CH]; Wolbruti 3, CH-7320 Sargans (CH). ZIMMERMANN, Fredy [CH/CH]; Staatsstrasse 113, CH-8888 Heiligkreuz (CH). JACOBSEN, Bent [DK/DK]; Lysholmparken 12, Osted, DK-4000 Roskilde (DK).

(74) Agent: GILL JENNINGS & EVERY; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).

(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: PROCESS AND APPARATUS FOR THE PRODUCTION OF A MINERAL FIBREBOARD



(57) Abstract

In a continuous process for the production of a bonded mineral fibreboard a fleece is compressed in the thickness direction to a first thickness substantially without simultaneous longitudinal compression and then compressed in length, no further thickness compression preferably taking place before the bonding of the fleece. During the longitudinal compression the precompressed fleece is clamped to a thickness in the range of between approximately 1 and 1.3, preferably between 1 and 1.1 of the nominal thickness of the finished product. The preferably single-stage longitudinal compression to 2 to 10 times the weight/unit area of the precompressed fleece is substantially carried out so as to avoid any pleating of the fleece and prevent any break-out of the fleece between the longitudinal compression unit (19; 19') and the bonding station (25). A multiply bonded mineral fibreboard may be obtained by longitudinally compressing of fleece and then dividing it into two or more layers, subjecting at least one of these layers to thickness and/or longitudinal compression and then recombining them.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

Process and apparatus for the production of a mineral fibreboard

This invention relates to a process and apparatus for the production of a mineral fibreboard.

Various improvements in the production of mineral fibreboards have been disclosed in recent years. A substantial improvement to the properties of mineral fibreboards can be obtained, for example, by reorienting the fibres in the production process so that they are aligned predominantly perpendicularly to the large surfaces of the board. The compressive strength and the tensile strength perpendicularly to the board plane can be substantially increased as a result.

Various processes are known whereby the fibres are reorientated such that the product acquires a pleated configuration but improved performance is usually obtained when the final product is substantially free of pleats. There have been various disclosures of processes for length compression of a fibre web either to form a pleated or a substantially unpleated product. One such process is in DE-A-1,635,620. It is apparent from the description and the drawings of this that the extent of length compression is quite small (35% being the maximum shown in the examples) and that this may be accompanied by a slight increase in thickness during the length compression.

Many processes involving length compression also include a significant thickness compression step after the length compression and before the final curing. For example, in EP 133,083, a web is subjected to significant length compression in a plurality of stages and is then subjected to thickness compression at the entry to the curing oven. The resultant product has a substantially isotropic fibre orientation.

Other disclosures of length compression conducted in such a manner as to avoid pleating exist in, for instance, US 4,567,078, WO 91/14816 and WO 94/16164.

It would be desirable to develop a length compression process which avoided significant pleating of the starting web but which resulted in considerable improvements in the properties, compared to those obtainable by known length compression processes. In particular, it would be desirable to make mineral fibre boards which have improved physical properties such as improved compressive strength and/or tensile strength and better insulation values. In particular, it would be desirable to be able to achieve these improved results with reduced resources, such as reduced amounts of fibre and possibly less binder.

According to the invention we provide a continuous process for the production of a bonded mineral fibreboard having a thickness t from a fleece having a thickness greater than 2t comprising

compressing the fleece depthwise, substantially without simultaneous longitudinal compression to a first thickness and to a weight w per unit area,

subsequently longitudinally compressing the fleece while the fleece is constrained to a second thickness and thereby producing a longitudinally compressed fleece,

transporting the longitudinally compressed fleece to a bonding station (25) and

bonding the fleece in the bonding station (25) to form a bonded mineral fibreboard,

characterised in that the first thickness is in the range 0.8 to 1.5 t, preferably between 0.9 and 1.3 t,

the second thickness is in the range between 1 to 1.3 t, preferably 1 to 1.1 t,

the longitudinal compression is conducted continuously or in one or more stages substantially without pleating of the fleece and produces a longitudinally compressed fleece with a weight per unit area of 2 to 10W, and

the fleece is constrained against break-out as it is transported between the longitudinal compression stage and bonding stage.

Since the compressed fleece has a weight per unit area of 2 to 10W, this is substantially equivalent to say that the longitudinal compression may be effected to approximately 0.5 to 0.1 times the original length of the web.

The invention also includes processes for the continuous production of a bonded mineral fibre board in which a fibre felt is precompressed in the direction of the thickness to a thickness of 1 to 3 times the thickness of the end product (preferably to substantially the same thickness as the nominal thickness of the end product) and is then subjected to a longitudinal compression by means of at least 2 conveyor pairs driven at different speeds to produce a longitudinally compressed felt and is then bonded at a bonding station (25) to give a bonded mineral fibreboard, characterised in that the thickness of the felt in the longitudinal compression stage and before the bonding station respectively is between approximately 0.9 and 1.3 times the thickness of the end product, the longitudinal compression is effected substantially without thickness compression, the longitudinal compression is effected to approximately 0.5 to 0.1 times the original length, the compression is effected in a continuous compression zone, and the felt is held in order to prevent break-out between the longitudinal compression unit and the bonding station.

The invention also includes novel apparatus, for instance as defined in the claims.

Because the fleece is under significant longitudinal compression, it is liable to buckle-up away from the conveyor by which it is being carried, and so appropriate means have to be applied to constrain the fleece against break-out (ie buckling away from the support) as it is being transported between the longitudinal compression unit and the bonding station. These constraining means can be a belt, rollers or other guides that will adequately confine the longitudinal compressed fleece to the desired

longitudinal path and prevent significant deviation of the fleece from the desired path.

It has surprisingly been found that products with significantly better properties can be produced by the novel process compared with the known prior art. Contrary to the known products, the new products are distinguished by a very homogeneous density. The fibres are uniformly felted and no preferential fibre orientation can be detected (Fig. 12). On an enlarged scale it has been found that the random-orientation fibres are arranged partially in a corrugated pattern.

In comparison with conventional processes, significant resource savings can be achieved with the process according to the invention. More particularly, the quantity of fibre required to achieve specific physical values can be up to 15 - 25% less. The products produced by the new process are therefore much lighter than conventional products having the same physical properties. Since the production costs are substantially related to the quantity of fibre used, significant cost savings can also be achieved with the new process.

In the precompression stage the relatively loose fleece is precompressed to a specific weight w (kg/m^2) and then further compressed to the end weight in the longitudinal compression unit, which can also be referred to as an optimisation unit. Contrary to expectations, the extraordinarily high compression of the already precompressed fleece to 2 to 10 times, preferably 2 to 6 times, the weight of the precompressed fleece, does not result in practice in any pleating at the fleece surface. A multiplication of the weight/unit area of the fleece or felt can be obtained by appropriate longitudinal compression of the fleece with substantially equal spacing of the upper and lower conveyors, for example in accordance with the nominal thickness of the end product.

Although the longitudinal compression of the fleece can be achieved in a series of stages, the longitudinal

compression of the fleece is preferably effected in one stage, the longitudinally compressed fleece and the bonded board having a weight per unit area of 2 - 6 times, preferably 2.5 - 5 times and most preferably 2.5 - 3.5 times the weight of the precompressed fleece. The resulting products have a high compressive strength and good insulation value.

Advantageously, longitudinal compression is effected by feeding the fleece by a first conveyor device to a second conveyor device, the second conveyor device being driven at a lower speed than the first conveyor device. The conveyor device can consist of belt, roller or chain conveyors. Preferably, however, roller conveyors are used, because the gross microdensities obtainable with these are extremely homogeneous. The roller diameter and the spacing between the rollers in the conveying direction or the spacing between the conveyors is preferably such as to render any break-out or pleating of the fleece substantially impossible. Preferably, the distance between two neighbouring rollers is between 1 and approximately 50 mm, advantageously between 2 and 30 mm and most preferably less than 20 mm. The permissible roller spacing depends substantially on the fleece density, the degree of longitudinal compression in the compression unit and the thickness of the board for production. With a small roller spacing it is possible to produce products of different thickness and high density. Although the rollers can be individually driven, in a preferred embodiment they are combined to form groups each comprising a plurality of rollers.

With the process according to the invention it is possible to produce products preferably having a density of between approximately 40 and 200 kg/m3. In one particularly advantageous variant, the fleece is stretched in the conveying direction after longitudinal compression. To this end, for example, the fleece can first be over-compressed, for example by 20 to 40%, with respect to the required

density of the end product, and then de-compressed by the stretching. This helps to avoid undesirable pleating of the fleece web. The gross microdensity can also be improved. Decompression by stretching can particularly be important in the case of high-density products, e.g. products having a density of more than 140 kg/m3. Compression and decompression operations can also be repeated.

The fleece may consist of glass wool fibres, rock wool fibres or other synthetic fibres. Preferably, however, the fleece consists substantially of rock wool fibres or other man-made vitreous fibres and contains non-cured binder. The binder content by weight is often between approximately 0.7 and 7%, generally 1 to 4%. The binder is preferably curable in a curing oven. Bonding of the fleece can, however, also be effected by needling or felting instead of or in addition to bonding by curing a bonding agent.

Advantageously, mineral fibres are used of an average length of between approximately 0.3 and 50 mm, preferably between approximately 0.5 and 15 mm and of a thickness of between approximately 1 to 12 μm, preferably between approximately 3 and 8 μm. However, mineral fibres of an average length of between approximately 1 and 10 mm, preferably between approximately 2 and 6 mm and of an average thickness between approximately 2 to 10 μm, preferably between approximately 3 to 6 or 7 μm, can be used. The average length of rock wool fibres, which are usually shorter than glass fibres, is as a rule 2 to 4 mm, and the average diameter is 3 to 4 μm.

Advantageously, during the deposition of the fleece on the conveyor the predominant orientation of the fibres is changed or partially evened out. This can be effected, for example, by means of a spinning member adapted to swing at an angle to the direction of transport, or by means of an air curtain. The density distribution of the fleece can thus be improved and the fibre orientation changed, this having a favourable effect on the mechanical properties of

the resulting products. Advantageously, the primary fleece is deposited in layers on the collecting belt by means of a pendulum belt adapted to swing at an angle to the direction of transport. Thus preferably the primary fleece is formed by cross-lapping. In this way the fibres are partially re-oriented and the homogeneity (transverse distribution) of the fleece deposited on the collecting belt can be improved.

Advantageously, 2 to approximately 60 layers, preferably between 2 and 40 to 50 layers, are deposited one upon the other. In these conditions a certain reorientation of the fibres is obtained.

The fleece can, for example, be deflected transversely of the direction of transport, a compression, more particularly longitudinal compression, being simultaneously effected.

According to a particularly preferred variant, the thickness and longitudinally compressed fleece is divided into two or more sub-webs parallel to the large surfaces, while to prevent any deformation in the thickness direction the sub-webs are each held at the opposite large surfaces. At least one of the webs is compressed in the direction of the thickness and/or longitudinally and the sub-webs are then combined and subsequently bonded. Multi-ply products can be produced by this process.

Although the adhesion of the sub-webs by the curing of the binder is normally sufficient, the contact surfaces of the sub-webs can be sprayed or impregnated with binder before being combined. Basically, the combined webs held together by suitable means can be thickness compressed once again. Advantageously, however, the webs are longitudinally compressed before bonding. The longitudinal compression can be effected in a ratio of 1.1 : 1 to maximum 2 : 1. The contact surfaces can be increased in size by a final longitudinal compression so that the bonding of the sub-webs is improved.

Although the novel apparatus may have individually driven rollers, it preferably comprises at least two roller groups of two or more rollers. Preferably, at least approximately 10 to 12 rollers are provided in the compression unit in order to compress the felt. The compressed felt can thus be given an advantageous corrugated fibre structure. Other advantageous embodiments are defined in the sub-claims. The invention also includes a process for the continuous production of a single-ply or multi-ply fibreboard, in which process a fibre felt is subjected to a precompression and, by means of at least two conveyor pairs driven at different speeds, a longitudinal compression or a longitudinal/thickness compression, and then fixed, characterised in that the fibre felt (20) is precompressed to approximately 1 to 3, usually about 1 to 1.5 times the nominal thickness of the finished product and then subjected to a longitudinal/thickness compression operation or just a longitudinal compression operation in an optimisation unit (19) by means of conveyors each having two opposite roller groups each comprising two or more rollers, the longitudinal compression being effected to 0.5 - 0.1 times the original length in a continuous or quasi-continuous compression zone and substantially the nominal thickness of the finished produce being attained in the optimisation unit.

The invention also includes apparatus for performing the process described above and comprising at least one collecting belt to receive a fibre felt, a precompression stage for compressing a fibre felt, at least two consecutive conveyors driven at different speeds for the longitudinal or longitudinal/thickness compression of the fibre felt and a curing oven for fixing the longitudinally and thickness-compressed fibre-felt, characterised by an optimisation unit (19) comprising conveyors each having two opposite roller groups each comprising two or more rollers, so that during operation a continuous or quasi-continuous

compression zone extending over a plurality of rollers or roller groups is obtained.

The preferred variant wherein the longitudinally compressed fleece is divided into two or more sub-webs at least one of which is then longitudinally compressed before they are recombined is a process of wider applicability and value than being utilised solely as a second stage in the process of the invention described above.

It is already known to split a web in the thickness direction into sub-webs, to compact one of them and then recombine them and cure them, for instance from CA-A-1057183, WO 88/00265 and EP-A-277,500. Known processes have various disadvantages. For instance the bottom web is often only precompressed so that the final product has relatively low compressive strength. Although compressive strength can be improved perpendicularly by pleating the fleece, this impairs the flexural strength. The processes also have the disadvantage that the bottom layer only undergoes slight compaction and substantially no rearrangement of fibre orientation, except possibly by pleating.

According to another aspect of the invention we provide a continuous process for the production of a twoply or multi-ply bonded mineral fibreboard from a mineral fibre fleece by precompression of the fleece, feeding the precompressed fleece to a separating device (41), separating the fleece by means of the separating device (41) into two or more sub-webs (43, 45), compressing at least one sub-web (45) in the direction of the thickness, followed by combining the sub-webs (43, 45') and transporting the same on to a bonding station (25) in which the fleece is bonded, characterised in that the mineral fibre fleece is longitudinally and/or thickness compressed, (preferably longitudinally compressed), in a compression unit (19) before the separating device (41) and break-out of the tensioned sub-webs (43, 45) between the compression

unit (19) and the bonding station (25) is prevented by constraining means (49, 50, 51, 59, 61, 63, 65).

In a preferred process we provide a process for the continuous production of a mineral fibre board having two or more layers of different densities by precompressing a fibre felt, feeding the precompressed felt to a separating device (41), separating the felt into two or more sub-webs (43, 45), compressing at least one sub-web (45) in the direction of the thickness, followed by combining the sub-webs (43, 45') and transporting the same on to a bonding station (25) in which the felt is bonded, characterised in that the fibre felt is longitudinally compressed before the separating device (41) in a compression unit (19) without compression in the direction of the thickness in a continuous compression zone in which the nominal thickness of the product is maintained, and in that break-out of the tensioned sub-webs (43, 45) between the compression unit (19) and the bonding station (25) is prevented by constraining means.

We also provide novel apparatus for the continuous production of a bonded mineral fibreboard from a mineral fibre fleece comprising means (27, 29) disposed consecutively in the conveying direction F for precompressing the fleece, first transport means (19) for transporting the fleece to a separating device (41), a separating device (41) for separating the fleece into two or more sub-webs (43, 45) means for compressing at least one sub-web (45) in the direction of the thickness, second transport means (23) for subsequently combining the sub-webs (43, 45') and transporting the same on to a bonding station (25) in which the fleece is bonded, a bonding station (25) for bonding the compressed fleece characterised in that the first transport means (19) form a compression unit which comprises at least two conveyor pairs (31, 33, 35, 37) disposed consecutively in the conveying direction, and in that means (49, 50, 51, 59, 61, 63, 65) are provided to prevent break-out of the tensioned

subwebs (43, 45) between the compression unit (19) and the bonding station (25).

The processes and apparatus of this aspect of the invention differ from known processes and apparatus essentially in that the precompressed web is compressed further in the thickness and/or longitudinal direction, particularly the longitudinal direction, by a compression unit, so that the sub-webs produced can already have relatively high densities and different fibre structures before being split. The advantage of this, for example, in the case of two-ply boards, is that the lower-density layer, unlike conventional boards, has a better compressive strength and tensile strength perpendicularly to the large surfaces. A specific tensile and compressive strength can therefore be achieved with reduced use of material, particularly a smaller quantity of fibre, compared with the known processes.

In order that the fleece webs under tension should not break-out or pleat between the compression unit and the bonding station, suitable hold-down means and/or conveyors are advantageously provided to hold the fleece webs at the large surfaces.

To form a highly compacted top layer, at least one of the split sub-webs can be thickness-compressed. A higher piercing strength can be obtained in this way. Advantageously, however, the one thickness-compressed sub-web can also be longitudinally compressed. Rolling the reoriented fibres flat by thickness compression may necessitate compensation of the resulting elongation.

To improve the bond between the sub-webs, the contact surfaces of the sub-webs can additionally be provided with binder before being combined. In many cases, however, the quantity of binder initially applied to the fibres is already sufficient to achieve a good bond between the sub-webs on curing of the binder. Another possibility for improving the bond between the sub-webs is to compress the combined webs in length before curing. By contracting the

webs, e.g. in a ratio of 1.1 : 1 to a maximum 2 : 1 it is possible to enlarge the contact surfaces and hence obtain a better bond between the layers.

One problem in connection with the continuous production of two-ply or multi-ply products may be soiling of the band knife used by the binder adhering to the fibres. One advantageous variant of the process therefore proposes continuously cleaning the separating device. This can be effected, for example, by means of a solvent jet, e.g. water, directed to the cutting edge of the band knife.

Advantageously, the longitudinal compression is effected by passing the fleece through a compression unit comprising a plurality of conveyor pairs disposed consecutively in the direction of conveyance, the speed of at least one conveyor pair being less than that of the preceding conveyor pair. Advantageously, the precompressed fleece is longitudinally compressed in at least one stage. Longitudinal compression enables the fibres to be reoriented so that, in particular, the compressive strength and tensile strength perpendicularly to the large surfaces are improved. As a result of the fibre structure optimisation it is possible to reduce the resources used.

Advantageously, for the production of products having a pleated fibre structure, the spacing of the opposite conveyors of a conveyor pair is set to approximately 0.5 to 0.1 times the spacing of the following conveyors, the conveying path defined by the two conveyor pairs being disposed substantially in alignment and the circumferential speed at least of the directly following pair being less than the circumferential speed of the preceding conveyor pair. In this way it is possible to produce a fleece web having a pleated fibre structure (Fig. 2).

Advantageously, before entry to the compression unit, the fleece is already compressed to approximately 0.8 to 1.5 times, preferably 0.9 to 1.3 times the nominal thickness and quite particularly preferably to the approximate nominal thickness of the finished product, so

that there is substantially only a longitudinal compression by the conveyors of the compression unit. The longitudinal compression can take place in a continuous compression zone in which the nominal thickness of the product is maintained. Surprisingly, a very homogeneous gross microdensity can be obtained if the fleece is already precompressed to approximately the nominal thickness of the finished product before the compression unit and is then only longitudinally compressed. The mineral fibre fleece is advantageously compressed in length by a factor of 2 to 10, preferably by a factor of 2.5 to 5 and quite particularly preferably by a factor of about 2.5 to 3.5. In some cases, for example when the density of the bottom subweb of the finished product is to be less than approximately 100 kg/m3, a simultaneous longitudinal and thickness compression may be indicated. The degree of thickness compression is advantageously less than 2 and preferably less than 1.5.

Although the conveyors of the compression unit may be conveyor belts, the conveyors in a particularly preferred embodiment are constructed as roller conveyors. Unlike conveyor belts, rollers have the advantage that the fleece is repeatedly expanded and compressed by the rollers during compression. As a result the products surprisingly have a very homogeneous gross microdensity (density distribution in a small unit volume) and very good mechanical properties, such as compressive, piercing and tensile strength in products of significantly reduced weight compared with conventional products. The fibres are uniformly felted and no preferential fibre orientation can be detected (Fig. 11). On an enlarged scale it has been found that the random-orientation fibres are partly arranged in a corrugated pattern. This type of fibre structure is designated a corrugated fibre structure by the inventors. Another desirable effect is the compaction of the fleece web surfaces which is possible by means of rollers.

Although the individual rollers can each be individually controllable, in one advantageous embodiment each roller conveyor comprises in each case two opposite groups of at least two rollers in each case, the rollers of a conveyor each being driven at the same circumferential speed. Since the rollers are combined in groups of at least two rollers, the compression unit and its control are greatly simplified.

Advantageously, the fleece is stretched in the conveying direction before the separating device. Expanding the fleece can prevent unwanted pleating or breaking-out of the fleece web, e.g. on transition from the compression unit to the separating device.

The fleece may consist of glass wool, rock wool or other synthetic fibres. Preferably, however, the fleece consists essentially of rock wool fibres and contains non-cured binder. The binder content by weight can be between approximately 0.7 and 4%. The binder is preferably curable in a curing oven. Bonding of the fleece can, however, be effected by needling or felting.

Advantageously, mineral fibres of an average length between approximately 0.3 and 50 mm, preferably between approximately 0.5 and 15 mm and of a thickness between approximately 1 to 12 μm, preferably between approximately 3 and 8 μm are used. However, it is also possible to use mineral fibres of an average length of between approximately 1 and 10 mm, preferably between approximately 2 and 6 mm and of an average thickness of between approximately 2 to 10 μm, preferably between approximately 3 to 7 μm. The average length of rock wool fibres, which are usually shorter than glass fibres, is as a rule 2 to 4 mm and the average diameter is 3 to 4 μm.

Advantageously, during the deposition of the fleece on the conveyor the predominant orientation of the fibres is changed or partially evened out. This can be effected, for example, by means of a spinning member adapted to swing at an angle to the direction of transport, or by means of air

curtain. The density distribution of the fleece can thus be improved and the fibre orientation changed, this having a favourable effect on the mechanical properties of the resulting products. Advantageously, the primary fleece is deposited on the collecting belt in layers by means of a pendulum belt adapted to swing at an angle to the transport direction. In this way the fibres are partially reoriented and the homogeneity (transverse distribution) of the fleece deposited on the collecting belt can be improved.

Advantageously, 2 to approximately 60 layers, preferably between 2 and 40 to 50 layers, are deposited one above the other. This results in some reorientation of the fibres.

The fleece can, for example, be deflected transversely of the direction of transport, while a compression, more particularly longitudinal compression, can take place at the same time.

The present invention also relates to an apparatus according to characterising features of claim 27. The apparatus according to the invention is characterised in that an additional compression unit is provided between the precompression stage and the separating device in order to compress the fleece further in the thickness and/or longitudinal direction, more particularly in the longitudinal direction, and reorient the fibres. Conveyor belts serve to maintain the fibre structure once obtained and prevent any deflection or break-out of the tensioned fleece.

Other advantageous embodiments are indicated in the sub-claims. According to a preferred exemplified embodiment, at least the separating device and the following hold-down device are adjustable independently of one another perpendicularly to the belt surface in the region of the multi-ply unit, so that the apparatus can be used selectively for the production of singleply or multi-ply products.

Advantageously, the means for compressing the at least one sub-web comprise at least two independently driven conveyor pairs. In this way the split sub-web can also be compressed in length. The conveyor pairs are advantageously roller conveyors, the roller spacing being adjustable. As a result the sub-webs can be compressed both in thickness and in length.

Advantageously, the bonding station is a curing oven, coolable feed rollers being provided before the said oven. In this way any adhesion of the binder to the rollers can be prevented and clogging obviated. In one advantageous embodiment, the circumferential speeds of the transport means between the separating device and the bonding station and the circumferential speed of the conveyor belts in the oven are individually adjustable so that, for example, compression or decompression can also be effected before the curing oven.

Exemplified embodiments of the invention are described below with reference to the drawings wherein:

Fig. 1 shows a mineral wool product produced by thickness compression and having a fibre orientation substantially parallel to the surface.

Fig. 2 shows a pleated product comprising a majority of fibres disposed perpendicularly to the surfaces.

Fig. 3 shows a two-ply product, the upper layer of which has increased density.

Fig. 4 shows a product with substantially homogeneous density and random-orientation fibres.

Fig. 5 shows a product in which a layer having random-orientation fibres is combined with a layer of increased density.

Fig. 6 is a simplified view of an apparatus for the production of a single-ply mineral fibreboard a) in a continuous process and in a continuous compression zone respectively and b) in a single-stage process.

Fig. 7 is a diagram showing the principle of an apparatus for the continuous production of a single-ply or

multi-ply mineral fibreboard of different densities; a) in a continuous process and in a continuous compression zone respectively and b) in a single-stage process.

Fig. 8 is a front elevation of a compression unit in detail.

Fig. 9 is a side elevation of the compression unit of Fig. 8.

Fig. 10 is a plan view of the compression unit of Fig. 8.

Fig. 11 shows the breaking zone of a) a board having a substantially parallel fibre orientation and b) and c) rock wool boards made by the new process and pulled apart perpendicularly to the board plane.

Fig. 12 is a perspective section through a two-ply board, the fibre structure being shown on an enlarged scale and Fig. 13 is a diagram showing various possible arrangements of four conveyor pairs disposed consecutively in the conveying direction.

Figs. 1 to 5 illustrate the fibre orientations frequently occurring in softboards. Boards having fibres disposed parallel to the surface (Fig. 1) have comparatively poor mechanical properties. To compensate for the disadvantages, the fibres are frequently strengthened with binder and the density increased.

Products having fibres arranged perpendicularly to the surface can be obtained if a board of the kind shown in Fig. 1 is cut into strips, the strips are turned through 90° and are then bundled. This type of manufacture is complex and correspondingly uneconomic. According to another type of manufacture, the fleece is pleated (pleating process, Fig. 2). These products have a substantially better compressive and tensile strength perpendicularly to the board plane than boards of the kind shown in Fig. 1. Boards having pleated fibres can bend and can therefore be used for insulating pipes or for lining curved areas. A disadvantage, on the other hand, is that these products tend to break along the pleats, and the

piercing strength is inadequate. Another disadvantage of the known products of this kind is that there may be relatively considerable differences in density within the board.

Fig. 3 shows a two-ply product, the top layer of which has an increased density. These products are suitable for applications requiring high tread strength or enhanced surface protection. As a result of the increased density of the top layer the average density can be reduced.

Fig. 4 shows a product with substantially isotropic fibre orientation with a substantially random fibre orientation. These products have excellent mechanical properties, such as high compressive, tread, and piercing strength, and high tensile strength perpendicularly to the board plane. They do not break and their thermal conductivity is substantially the same as the products shown in Fig. 1. Generally, these products are lighter than comparable products having substantially parallel fibres for comparable or improved mechanical properties.

Fig. 5 shows a product in which the advantages of increased density of the top layer and of the fibre structure shown in Fig. 4 are combined. The object of the invention is particularly further to improve the properties of products of the kind shown in Figs. 4 and 5.

The apparatus 11' shown in Fig. 6 for performing the process according to the invention comprises, as considered in the conveying direction F, a precompression stage 17', an optimisation or compression unit 19' adjoining the precompression stage 17' and consisting of two conveyor pairs 30, 32 for compressing the felt or fleece, and also a conveyor belt 40 and a hold-down belt 42 and feed rollers 63, 65 for conveying the compressed fleece to a curing oven 25. Finally, conveyor belts 67, 67' are provided in the curing oven 25 to transport the compressed fleece through the oven and hold the same at the opposite large surfaces during curing of the binder.

The precompression stage 17′ consists of a lower conveyor belt 27 and a pressing belt 29. By means of the precompression stage 17′, the primary fleece deposited preferably in layers on a collecting belt 15 is precompressed to such an extent that the fleece denoted by reference 20 can be introduced into the compression unit 19′. For this purpose the pressing belt 29 is adjustable as to height.

The conveyor pairs 30, 32 of the compression unit 19′ consist of upper and lower roller groups 30′, 30′′ and 32′, 32′′ each consisting of six rollers 39. The upper and lower roller groups 30′, 30′′; 32′, 32′′ each have a separate drive (not shown in detail) so that the conveyors can be driven at different speeds respectively. Also, the upper roller group 30′, 32′ are adjustable as to height, so that the apparatus 11′ can be used for the production of products of different thicknesses. The distance between the upper and lower roller groups 30′, 30′′i 32′, 32′′ is preferably identical.

To perform the process according to the invention, the fleece is precompressed in the precompression stage to approximately the nominal thickness of the finished product and then longitudinally compressed with a conveyor spacing corresponding approximately to the nominal thickness of the finished product. In these circumstances the conveyor 30 is driven at a first speed and the conveyor 32 at a second speed which is usually not more than half the first speed so that a corresponding longitudinal compression of the fleece 20 results. In principle, another conveyor could be provided in order to expand the fleece somewhat after longitudinal compression. The latter step can prevent the highly compressed fleece from pleating or breaking out in the upward direction on transport into the curing oven 25.

The compression unit 19 is followed by a conveyor belt 40 and a hold-down device 42 in order to constrain the compressed fleece 20 against breaking out, ie buckling upwards off the conveyor 40. The hold-down device 42

consists of an uncoilable relatively heavy belt which is placed on the conveyed fleece web. The belt can be additionally loaded by applied weights. Feed rollers 63, 65 are provided before the curing oven 25 and are preferably coolable. Advantageously, the distances between the lower and upper roller groups are each set to approximately the nominal thickness of the end product. This has the advantage that once the fibre orientation has been set in the compression unit 19 it is no longer changed.

The apparatus 11 shown in Fig. 7 differs from that shown in Fig. 6 basically in that the compression unit 19 has four conveyors each with four rollers. A multiply unit is also provided which can be used for the production of multi-ply boards and can in principle also be used together with the apparatus 11'. For simplification, the same references are used in the following description as in the description of the apparatus 11' for like parts.

The apparatus 11 shown in Fig. 7 for the production of mineral fibre boards comprises essentially, arranged consecutively in the direction of conveyance F, a pendulum belt 13 and a collecting belt 15 for the respective deposition and reception of fibres produced by a fibre production unit (not shown in detail), and a precompression stage 17 and an optimisation or compression unit 19 for forming a felt or fleece 20 having optimised fibre orientation and homogeneity. The compression unit 19 for optimising the compression is followed by an optional multi-ply unit 21 which can be used for the production of multi-ply mineral fibre boards. The multi-ply unit 21 is followed by transport means 23 which hold the compressed fleece clamped at the opposite large surfaces and feed the same to a bonding station, e.g. a curing oven 25.

The above-mentioned fibre production unit serves for the continuous production of fibres by one of the known methods, e.g. the cascade spinning process. The fibres produced, also termed the "primary fleece", are sprayed (not shown) with a binder and pass by means of a conveyor

(not shown) to the pendulum belt 13. The latter belt is situated above the collecting belt 15 and swings transversely to the direction of transport of the collecting belt 15. A different orientation of the pendulum movement, e.g. in the transport direction, is however also possible. As a result of the pendulum movement, the primary fleece 26 is deposited as cross-laps, as will be seen from Fig. 7, on the forwardly moving collecting belt 15, depending on the speed of the latter and the frequency of the pendulum movement. Other means, for example gas jets, are however possible for the production of the most random possible fibre orientation on the collecting belt. As a result of the advance movement of the collecting belt 15, the orientation of the fibres is predominantly at an angle to the direction of transport. Viewed from above, the fibres of two superposed fleece layers extend substantially crosswise.

The precompression stage 17 consists of a lower conveyor belt 27 and a pressing belt 29. The latter is adjustable as to height so that the fleece 26 can be precompressed to different degrees. The precompression stage 17 provides precompression and a certain homogenisation of the relatively loose fleece 20 before the same is introduced into the optimisation unit 19. The two belts 27, 29 preferably have separate independent drives so that they can be operated at different circumferential speeds.

According to the exemplified embodiment shown, the optimisation unit 19 consists of a plurality of conveyors or conveyor pairs 31, 33, 35, 37. Each pair 31, 33, 35, 37 has a lower and an upper roller group each consisting of four rollers 39. The clearance between the individual roller groups 31′, 31′′; 33′, 33′′; 35′, 35′′; 37′, 37′′ is adjustable. The roller groups are also adapted to be inclined relatively to one another preferably in the direction of transport. The latter property enables the fleece 20 to be continuously compressed in thickness or be

decompressed on passage through a conveyor pair 31, 33, 35, 37.

A number of different formulations for the fleece optimisation can be obtained as a result of the possibility of adjusting the distance between the opposite roller groups and their speeds. In this way the product properties can be quite different. Also, because of these adjustment facilities, the fibre structure can be controllably optimised and, for example, undesirable pleating at the fleece surface can be prevented.

At least the lower and upper roller groups 31'' and 31' respectively of the first conveyor pair 31 are adjustable as to height. This enables the fleece to be subjected to bending, as shown in Fig. 7, for example in order to smooth and compact the fleece surface.

The upper and lower roller groups 31', 31''; 33', 33''; 35', 35''; 37', 37'' of the conveyor pairs 31, 33, 35, 37 each have a separate drive not shown in detail in Fig. 7. The drives used are preferably infinitely variable within a specific range, so that, for example, the upper and lower roller groups can have different circumferential speeds. A slightly higher circumferential speed of the upper roller group is necessary, for example, if the same is disposed, not horizontally, but at an angle to the lower roller group.

Figs. 8 to 10 show an exemplified embodiment of a compression unit 19 in which the conveyors with the roller groups 31', 31''; 33', 33''; 35', 35''; 37', 37'' having the rollers 39 are disposed on a supporting structure 71. Chain wheels 115 (Fig. 10) are provided at one end of each of the rollers 39. Each four or five rollers 39 are interconnected by drive chains (not shown) and form a roller group. A drive 117', 117'', 117''', 117'''', 118', 118'', 118''', 118'''' is provided for each roller group.

The upper and lower roller groups 31', 31'' of the first conveyor pair 31 considered in the direction of conveyance (Fig. 9, arrow F) are vertically adjustable. The

vertical adjustment of the upper roller group 31′ is effected by means of a drive member 81 which drives the spindles 73, 73′ via the Cardan shafts 77, 77′.

A drive member 83 driving the spindles 75, 75′ via the Cardan shafts 79, 79′ is used for the vertical adjustment of the bottom roller group 31′′.

Unlike the first roller groups 31′, 31′′, the position of the remaining roller groups is either not adjustable (at the bottom) or adjustable only jointly (at the top). As will be seen particularly from Figs. 8 and 9, the rear bottom three rollers groups 33′′, 35′′, 37′′ as considered in the direction of conveyance are disposed on a stationary frame 85 while the upper three roller groups 33′, 35′, 37′ are disposed on a vertically adjustable frame 87. The latter frame 87 is vertically adjustable at the top part of the supporting structure 71. Linear guides 93 at the columns 95, 95′, 97, 97′ provide vertical guidance of the frame 87. A drive member 103 which by way of the Cardan shafts 99, 99′, 101, 101′ drives the spindles 89, 89′, 91, 91′ arranged in pairs on the supporting structure 71 is provided for vertical adjustment of the frame 87.

The upper roller groups 33′, 35′, 37′, the last of which has 5 rollers 39, are disposed on support rails 105 pivotally connected to the frame 87 by the pivot 107. In the exemplified embodiment illustrated, the front end of the rails 105 as considered in the direction of conveyance is connected to the vertically adjustable frame 87 by another pair of spindles 109, 109′. By adjustment of the spindles 109, 109′ it is possible to swing the support rails 105 upwardly or downwardly out of the horizontal so that, for example, it is possible to form a path tapering in the direction of conveyance F. The spindles 109, 109′ are also interconnected via Cardan shafts 111, 111′ so that here again one drive 113 is sufficient to adjust them.

Fig. 13 shows various possibilities of how four conveyor pairs can be arranged in principle. The adjustments according to Figs. 13b and 13c, however, cannot

be made with the compression unit according to Figs. 8 to 10. An arrangement of the roller groups 31′, 31′′, 33′, 33′′, 35′, 35′′, 37′, 37′′ according to Fig. 13d is advisable, for example, if light products are to be made.

The optimisation unit 19 comprising a plurality of conveyor pairs is followed by the optional multi-ply unit 21, which in the exemplified embodiment illustrated is in the form of a dual density device. This comprises a separating device 41, for example, a band saw or a band knife, which is shown only in outline in Fig. 7 for separating the compressed fleece 20 into two webs 43 and 45. The multi-ply unit 21 also comprises conveyors 47, 49, 50 and 51, e.g. conveyor belts, which fix the compressed sub-webs 43, 45 in thickness. Any gaps occurring for geometric reasons between the separating device and, for example, the conveyor belt 49 or 50 can be bridged where possible by guide plates. These prevent the fleece web 43, which is compressed to varying degrees, from breaking out.

The separating device 41 and following conveyor is preferably adjustable as to height. This enables the fleece emerging from the compression unit 19 to be cut into lower and upper webs 43, 45 of practically any thickness. In addition, the separating device 41 and the conveyor belt 49 can also be displaced independently of one another and upwardly to an extent such that they are disposed outside the range of transport of the fleece. The conveyor belt 49 then serves as a hold-down belt. Owing to the vertical adjustability, the apparatus 11 can be used optionally for the production of single-ply or multi-ply boards. Basically, a plurality of separating devices and corresponding hold-down belts can be provided to enable boards to be produced with three or even more layers. Also, the distance between the upper and lower rollers is adjustable so that outer layers of different thicknesses can be made.

Two conveyor pairs 53, 54 provided after the conveyors 50, 51 serve for thickness and longitudinal compression of

the upper web 45. The conveyor pairs 53, 54 preferably comprise rollers S5, which are combined in each case to form upper and lower roller groups with three rollers in each case. The conveyor pairs 53, 54 are each drivable at different circumferential speeds so that the elongations which may occur as a result of thickness compression can be compensated by subsequent longitudinal compression. Also, the distance between the upper and lower rollers is adjustable so that outer layers of different thicknesses can be made.

Conveyor belts, chutes and/or guide plates (not shown in detail) combine the compressed web 45' with the lower web 43. In most cases a hold-down belt for the highly compressed web 45' can be dispensed with. A metering device 57 for a binder is provided in the zone where the webs 43, 45 meet. With this arrangement it is possible to apply binder to the contact surfaces of the upper and/or lower webs 43, 45' so that a better bonding is obtained after curing of the binder. In most cases, particularly if any elongations occurring have been compensated previously, a metering device 57 can also be dispensed with.

Feed belts 59, 61 and feed rollers 63, 65 press the combined webs 43, 45' together and transport the same into the curing oven 25. The circumferential speeds of the feed belts 59, 61 and feed rollers 63, 65 are advantageously individually adjustable so that compression or decompression of the compressed webs 43, 45' can be effected as required. At least the feed rollers 63, 65 are preferably coolable. Air-permeable conveyor belts 67, 67' are preferably provided in the curing oven 25. The belts 67, 67' hold the webs 43, 45' together during the curing process and thus substantially determine the nominal thickness of the finished boards. The belts 67, 67', like the conveyors 59, 61, 63, 65, are vertically adjustable and can thus be adjusted to the fleece thicknesses coming from the multi-ply unit 21 or the compression unit 19.

The production of the multi-ply board can be carried out as follows: the primary fleece delivered from a collecting chamber (not shown) and provided with binder and, in the case of rock wool fibres usually of a weight of about 200 - 800 g/m2, preferably 200 400 g/m2, with an approximately average thickness of 15 - 20 mm, or frequently up to 75 mm, is fed to the pendulum belt 13. The latter deposits the primary fleece on the continuously advancing collecting belt 15. Depending on the speed of the latter belt 15 and the frequency of the pendulum belt 13, a larger or smaller number of fleece layers is formed on the belt 15 in the vertical direction. The number of layers is selected according to the required board properties, e.g. weight, compressive strength etc., of the end product. The number of layers also depends on the fibre formulation, i.e. the individual fibre processing stages between the fibre production unit and the curing oven 25. Usually 2 to 40 to 50 layers are deposited on the collecting belt 15.

Depositing the primary fleece 26 by means of the pendulum belt 13 not only provides good transverse distribution of the fibre material on the collecting belt 15, but also contributes to uniform fibre orientation and a certain homogenisation. The fibre orientation can be further controllably influenced by changing the direction of the pendulum movement.

The deposited fleece is subjected to a precompression in the precompression stage 17. The precompression is usually such that the fleece can be engaged by the rollers of the first conveyor pair (required nominal thickness plus at maximum approximately 40% of the roller diameter). Some deflection of the fleece after precompression is desirable so that, on entry into the compression unit, sufficient adhesion between the fleece and the rollers is achieved to give the required reorientation of the fibres. Since, in the case of products having a density of less than approximately 80 to 90 kg/m3 the expansion forces prevailing in the fleece during longitudinal compression

are much lower, a moderate thickness compression in addition to the longitudinal compression is usually necessary in the production of these products in order to set the required tension and avoid undesirable pleating at the fleece surface.

In the case of doubling, i.e. when the primary fleece is deposited in layers, the fleece surfaces have steps showing to varying degrees. These steps can be at least partially evened out in the precompression stage 17, by driving the upper belt 29 at a slightly higher speed than would be necessary for further transport.

The partially smoothed fleece can be subjected to further smoothing in the optimisation unit 19. To this end, for example, the first and second conveyor pairs can be disposed so as to be out of alignment. It is also possible for any other pairs of conveyors to be disposed out of alignment. The out-of-alignment arrangement subjects the conveyed fleece 20 to a bending or transverse deflection, which can effect smoothing of the fleece surfaces. The smoothing effect can be enhanced if the second conveyor pair runs somewhat more slowly than the first.

Preferably, a longitudinal compression of 2:1 to 6:1 (corresponding to the circumferential speeds of the first and the last conveyor pairs 31 and 37) is effected in the compression unit 19 substantially with a roller spacing corresponding to the nominal thickness of the board being produced (i.e. compaction by longitudinal compression without thickness compression). In the case of lighter products, however, a longitudinal compression together with simultaneous moderate thickness compression may be advantageous. In the case of a single speed graduation, each two conveyor pairs 31, 33 and 35, 37 can be driven jointly by one drive.

Although conveyor belts can be used for compression, rollers are preferred, because the tendency to pleating at the fleece surfaces is relatively minor, even with a considerable degree of longitudinal compression. The fleece

can be greatly longitudinally compressed with rollers 39 without appreciable pleating at the fleece surface. One possible explanation for this is that there is only a slight adhesion between the rollers and the fleece. The rollers also promote the reorientation of the fibres, since the fleece can expand somewhat between the rollers in each case but without pleating.

This results in good compaction of the fibre felt in the interior and at the surface.

In the multi-ply unit 21 the compressed fleece can be separated into two or more webs 43, 45. It is also possible to omit the multi-ply unit or position it outside the conveying path and feed the fleece with the optimised fibre structure to the curing oven direct.

Separation of the fleece 20 is effected by a band saw or a band knife in manner known per se. The upper web 45 with the optimised fibre structure is then subjected to a thickness and longitudinal compression. In this, the fibres of the upper layer 45 are further compacted by the thickness and subsequent longitudinal compression. The thickness-compressed web 45′ is then returned to the continuously moving lower web 43.

The compressed fleece 43, 45′, more particularly the web 43 under tension, is guided between the compression stage 19 and the curing oven 25 by the conveyors 47, 49, 59, 61, 63, 65, for example belts, chains or roller systems, preferably conveyor belts, in order to prevent any break-out or bulging.

In the curing oven 25 the binder in the fleece is cured. Curing of the binder takes place at temperatures between 180 and 300°C, preferably at about 200 to 250°C. The binder also ensures a firm bonding between the two webs 43, 45′ of low and high gross density.

To improve the adhesion of the webs 43, 45′, the contact points thereof can be provided with a solid or liquid adhesive (metering device 57) on the multi-ply unit before being combined.

Alternatively, or in addition, the bonding between the two webs 43 and 45' can be improved if the webs are contracted somewhat before the curing oven 25, preferably in a ratio of 1.1:1 to 2:1. Depending on the degree of contraction, this may result in some pleating of the webs. The contraction results in the contact surfaces increasing in size and the adhesion/felting of the webs can thus be improved.

With the above-described apparatus according to the invention, the fleece or felt is longitudinally compressed preferably in a single stage. Alternatively, the apparatus can also be so operated that a plurality of compression zones or a continuous compression zone form during the compression.

Example 1:

Board type Single-ply
Fibre material Rock wool
Board thickness 100 mm
Gross density About 90 kg/m3
Binder Modified phenolic resin
Average fibre length From about 3 to 4 mm
Average fibre diameter From 3 to 4 μm
Precompression Approximately nominal thickness
Longitudinal compression 3 : 1
Compressive strength at 10%
deflection 0.035 N/mm2
Pull-off strength 0.020 N/mm2
(Delamination)

Example 2:

Board type 2-ply
Fibre material Rock wool
Board thickness 100 mm
Outer layer thickness About 20 mm
Substrate thickness About 80 mm
Average gross density About 90 kg/m3
Outer layer gross density 155 kg/m3
Substrate gross density 75 kg/m3

Binder Modified phenolic resin
Average fibre length From about 0.5 to 10 mm
Average fibre diameter From 3 to 6 μm
Precompression Approximately 1.5 nominal thickness
Thickness compression 1.8 : 1 to 1.1 : 1
Longitudinal compression 3 : 1
Compressive strength at 10% deflection 0.025 - 0.030 N/mm2
Pull-off strength 0.013 - 0.018 N/mm2 (Delamination)

<u>Example 3:</u>

Board type 2-ply
Fibre material Rock wool
Board thickness 100 mm
Outer layer thickness About 20 mm
Substrate thickness About 80 mm
Average gross density About 90 kg/m3
Outer layer gross density 155 kg/m3
Substrate gross density 75 kg/m3
Binder Modified phenolic resin
Average fibre length About 3 to 4 mm
Average fibre diameter From 3 to 4 μm
Precompression Approximately 1.8 to 1.5 times nominal thickness
Thickness compression 1.5 : 1.1 : 1
Longitudinal compression 3 : 1
Compressive strength at 10% deflection 0.025 - 0.030 N/mm2
Pull-off strength (Delamination) 0.013 - 0.018 N/mm2
Diameter of rollers used 80 mm.

In comparison with boards having a non-optimised fibre structure and density, the weight in boards produced by the new process can be reduced by up to 25 to 40% for otherwise substantially identical mechanical properties. The tensile strength perpendicularly to the board plane is greatly

improved, this being evident from the highly structured breaking zone (Figs. 11b and 11c).

Products according to the invention can be used for any of the conventional purposes of synthetic fibres, e.g. for boards, webs, used for thermal insulation, fireproofing and fire protection or soundproofing and sound control, or in suitable form in horticulture as a growth medium.

CLAIMS

1. A continuous process for the production of a bonded mineral fibreboard having a thickness from a fleece having a thickness greater than 2t comprising

compressing the fleece depthwise, substantially without simultaneous longitudinal compression to a first thickness and to a weight w per unit area,

subsequently longitudinally compressing the fleece while the fleece is constrained to a second thickness and thereby producing a longitudinally compressed fleece,

transporting the longitudinally compressed fleece to a bonding station (25) and

bonding the fleece in the bonding station (25) to form a bonded mineral fibreboard,

characterised in that the first thickness is in the range 0.8 to 1.5 t, preferably between 0.9 and 1.3 t,

the second thickness is in the range between 1 to 1.3 t, preferably 1 to 1.1 t,

the longitudinal compression is conducted continuously or in one or more stages substantially without pleating of the fleece and produces a longitudinally compressed fleece with a weight per unit area of 2 to 10W, and

the fleece is constrained against break-out as it is transported between the longitudinal compression and the bonding station.

2. A process according to claim 1, characterised in that the longitudinal compression of the fleece is effected in one stage.

3. A process according to claim 1 or claim 2 in which the longitudinally compressed fleece and the bonded board have a weight per unit area of 2 to 6 w, preferably 2.5 to 4 w.

4. A process according to any of claims 1 to 3, in which the longitudinal compression is effected by feeding the fleece by means of a first conveyor device (30) to a second conveyor device (32), the second conveyor device (32) being driven at a lower speed than the first conveyor device and in which each conveyor device (30, 32) comprises two

opposite roller groups (30', 30'') each comprising at least two spaced-apart rollers (39).

5. A process according to claim 4 in which the opposite roller groups of at least one conveyor device (30, 32; 31, 33, 35, 37) are driven at different speeds.

6. A process according to any preceding claim in which the fleece is longitudinally stretched after the longitudinal compression.

7. A process according to any preceding claim in which the fleece is formed of man-made vitreous fibres, preferably Rockwool fibres, and contains uncured binder and the binder is cured by heating at the bonding station.

8. A process according to any preceding claim in which the fleece is formed by cross-lapping.

9. A process according to any preceding claim in which the longitudinally compressed fleece is, before the bonding station, divided parallel to the major surfaces into two or more sub-webs and each sub-web is constrained against break-out as it travels towards the bonding station and at least one of webs is compressed in the thickness direction and/or length direction and the sub-webs are then combined and bonded at the bonding station.

10. A process according to claim 9 in which the contact surfaces are provided with binder before being combined.

11. A process according to claim 9 or claim 10 characterised in that the combined webs are longitudinally compressed before the bonding station.

12. A process for the continuous production of a bonded mineral fibre board in which a fibre felt is precompressed in the direction of thickness to a thickness of 1 to 3 times the end product and is then subjected to longitudinally compression by means of at least two conveyor pairs driven at different speeds to produce a longitudinally compressed felt and is then bonded at a bonding station (25) to give a bonded mineral fibreboard, characterised in that the thickness of the felt in the longitudinal compression stage and before the bonding

station respectively is between approximately 0.9 and 1.3 times the thickness of the end product, the longitudinal compression is effected substantially without thickness compression, the longitudinal compression is effected to approximately 0.5 to 0.1 times the original length, the compression is effected in a continuous compression zone, and the felt is held in order to prevent break-out between the longitudinal compression unit (19, 19-) and the bonding station (25).

13. A process according to claim 18, characterised in that the thickness of the felt in the longitudinal compression zone is substantially the same as the nominal thickness of the end product.

14. A product comprising fibreboard made by a process according to any preceding claim.

15. Apparatus for the continuous production of a bonded mineral board from a mineral fibre fleece comprising conveyor means (19, 40; 19, 23) for conveying the fleece to a bonding station (25), a device (17) for thickness compression of the fleece, a fleece longitudinal compression device (19; 19′) following the thickness compression device (17), a bonding station (25) for bonding the longitudinally compressed fleece, and means (59, 61; 40, 42) to prevent break-out of the fleece between the longitudinal compression device and the bonding station (25), characterised by at least two roller conveyors (30, 32) disposed consecutively in the conveying direction, each roller conveyor (30, 32) comprising two opposite groups of at least two rollers (39) in each case, the opposite roller groups forming a conveying path (F) for the fleece, drive means to drive the rollers (39) of each group substantially at the same circumferential speed, means for controlling the circumferential speed of the rollers (39, 39′) of each individual group independently of the speed of the rollers in each other group, and means for adjusting the spacing between the opposite roller groups (30′, 30′′; 32′, 32′′)

of the conveyors (30, 32) independently of the spacing of the rollers in other conveyors.

16. Apparatus according to claim 15, characterised in that two roller conveyors (30, 32) disposed consecutively in the conveying direction (F) are provided.

17. Apparatus according to claim 15 or 16, characterised in that each roller group comprises two to eight rollers, preferably four to six consecutive rollers.

18. Apparatus according to any one of claims 15 to 17, characterised in that at least one of the roller conveyors (30, 32) has means for inclining the opposite roller groups relatively to one another, for example in order to produce a fleece web tapering in the conveying direction.

19. Apparatus according to any one of claims 15 to 18, characterised in that the roller diameter and the spacing between the rollers (39) in the conveying direction is such as substantially prevent any break-out or pleating of the fleece.

20. Apparatus according to any one of claims 15 to 19, characterised in that the roller diameter is less than approximately 18 cm and is preferably between approximately 60 and 160 mm and particularly preferably between 80 and 120 mm.

21. Apparatus according to any one of claims 15 to 19 characterised in that at least the first conveyor (30) has means for adjusting the position of the conveying path through said conveyor relatively to the position of the conveying path through the following conveyor or conveyors (32).

22. Apparatus according to any one of claims 15 to 21, characterised in that the conveyors (30, 32) are disposed horizontally.

23. Apparatus according to any one of claims 15 to 22, characterised in that a separating device (41) for separating the fleece into two or more sub-webs is provided between the roller conveyors (31, 33, 35, 37) and the bonding station (25), in that at least one compression

stage (53, 54) is provided for the thickness and/or longitudinal compression of at least one sub-web and in that conveyors (59, 61, 63, 65) are provided for holding the compressed fleece and the sub-webs on the path to the bonding station (25) in order to prevent any deformation in the direction of the thickness or break-out.

24. Apparatus according to claim 23, characterised in that the separating device (41) and at least the conveyor (47) are adjustable as to height so that the apparatus can be used optionally for the production of single-ply or multi-ply products.

25. Apparatus according to claims 23 or 24, characterised in that means (57) are provided for the metered supply of a binding agent to the mutual contact surfaces of the sub-webs.

26. Apparatus according to any one of claims 15 to 25, characterised in that means are provided to drive the conveyor means between the compression stage and the bonding station and in the bonding station independently of one another.

27. A continuous process for the production of a twoply or multi-ply bonded mineral fibreboard from a mineral fibre fleece by precompression of the fleece, feeding the precompressed fleece to a separating device (41), separating the fleece by means of the separating device (41) into two or more sub-webs (43, 45), compressing at least one sub-web (45) in the direction of the thickness, followed by combining the sub-webs (43, 45') and transporting the same on to a bonding station (25) in which the fleece is bonded, characterised in that the mineral fibre fleece is longitudinally and/or thickness compressed, (preferably longitudinally compressed), in a compression unit (19) before the separating device (41) and break-out of the tensioned sub-webs (43, 45) between the compression unit (19) and the bonding station (25) is prevented by constraining means (49, 50, 51, 59, 61, 63, 65).

28. A process according to claim 27, characterised in that at least the one thickness-compressed sub-web (45) is longitudinally compressed.

29. A process according to claims 27 or 28, characterised in that the contact surfaces of the sub-webs (44, 45) are provided with binder before being combined.

30. A process according to any one of claims 27 to 29, characterised in that the combined webs (44, 45') are longitudinally compressed before bonding.

31. A process according to any one of claims 27 to 30, characterised in that the separating device (41) is continuously cleaned.

32. A process according to any one of claims 27 to 31, characterised in that the fleece is longitudinally compressed before the separating device in a compression unit in a continuous compression zone or in stages substantially without thickness compression taking place.

33. A process according to any preceding claim characterised in that before entering the compression unit (21) the fleece is precompressed to approximately 0.8 to 1.5 times, preferably 0.9 to 1.3 times the nominal thickness of the finished product.

34. A process according to claim 32 or 33 in which the compression is effected in one stage.

35. A process according to any preceding claim in which the fleece is compressed to approximately the nominal thickness of the finished product at the latest by the last conveyor.

36. A process for the continuous production of a mineral fibre board having two or more layers of different densities by precompressing a fibre felt, feeding the precompressed felt to a separating device (41), separating the felt into two or more sub-webs (43, 45), compressing at least one sub-web (45) in the direction of the thickness, followed by combining the sub-webs (43, 45') and transporting the same on to a bonding station (25) in which the felt is bonded, characterised in that the fibre felt is

longitudinally compressed before the separating device (41) in a compression unit (19) without compression in the direction of the thickness in a continuous compression zone in which the nominal thickness of the product is maintained, and in that break-out of the tensioned sub-webs (43, 45) between the compression unit (19) and the bonding station (25) is prevented by constraining means.

37. Apparatus for the continuous production of a bonded mineral fibreboard from a mineral fibre fleece comprising means (27, 29) disposed consecutively in the conveying direction F for precompressing the fleece, first transport means (19) for transporting the fleece to a separating device (41), a separating device (41) for separating the fleece into two or more sub-webs (43, 45) means for compressing at least one sub-web (45) in the direction of the thickness, second transport means (23) for subsequently combining the sub-webs (43, 45') and transporting the same on to a bonding station (25) in which the fleece is bonded, a bonding station (25) for bonding the compressed fleece characterised in that the first transport means (19) form a compression unit which comprises at least two conveyor pairs (31, 33, 35, 37) disposed consecutively in the conveying direction, and in that means (49, 50, 51, 59, 61, 63, 65) are provided to prevent break-out of the tensioned subwebs (43, 45) between the compression unit (19) and the bonding station (25).

38. Apparatus according to claim 37, characterised in that means (57) are provided to provide the sub-webs with binder before they are re-combined.

39. Apparatus according to claim 37 or 38, characterised in that the separating device (41) consists of a band knife or a band saw.

40. Apparatus according to any one of claims 37 to 39, characterised in that a cleaning device is provided for the continuous or intermittent cleaning of the band knife or band saw.

41. Apparatus according to any one of claims 37 to 40, characterised in that at least the separating device (41) and the following hold-down device (49) are vertically adjustable in the region of the multi-ply unit (21).

42. Apparatus according to any of claims 37 to 41 characterised in that for the production of substantially pleated products the spacing of the opposite conveyors of a conveyor pair (31, 33, 35) is adjustable to approximately 0.5 to 0.1 times the spacing of the conveyors of the following conveyor pair (33, 35, 37) and in that the conveying path defined by the two conveyor pairs is substantially in alignment.

Fig.1.

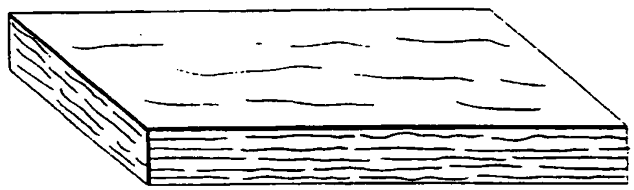


Fig.2.

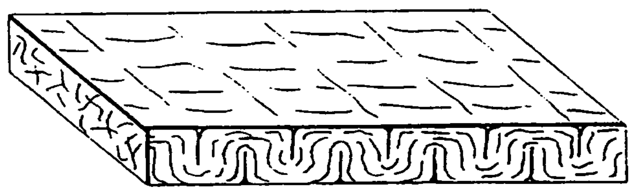


Fig.3.

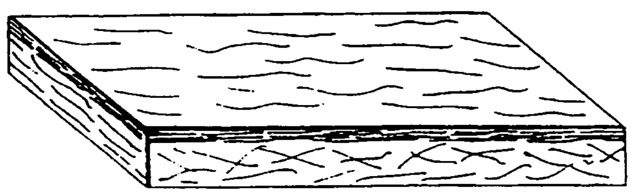


Fig.4.

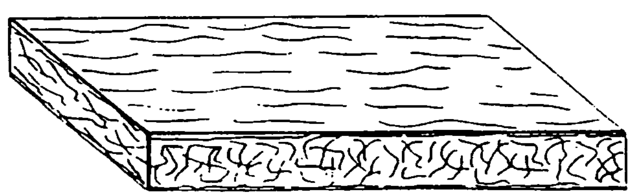
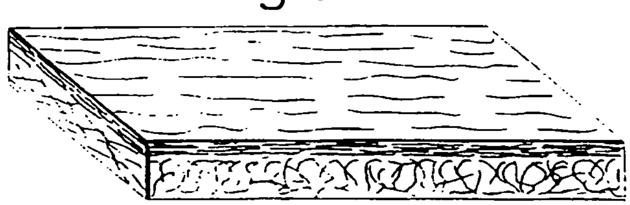


Fig.5.



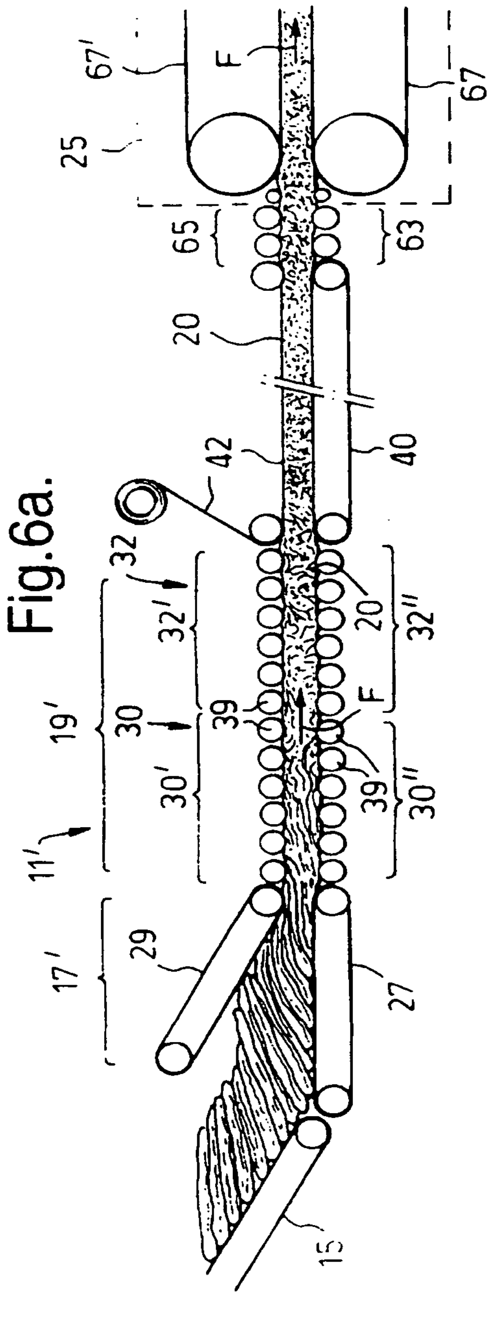

17'
29
27
15
11'
19'
30
30'
30"
39
39
F
32
32'
32"
20
20
42
40
65
63
25
67'
67
F

Fig.6a.

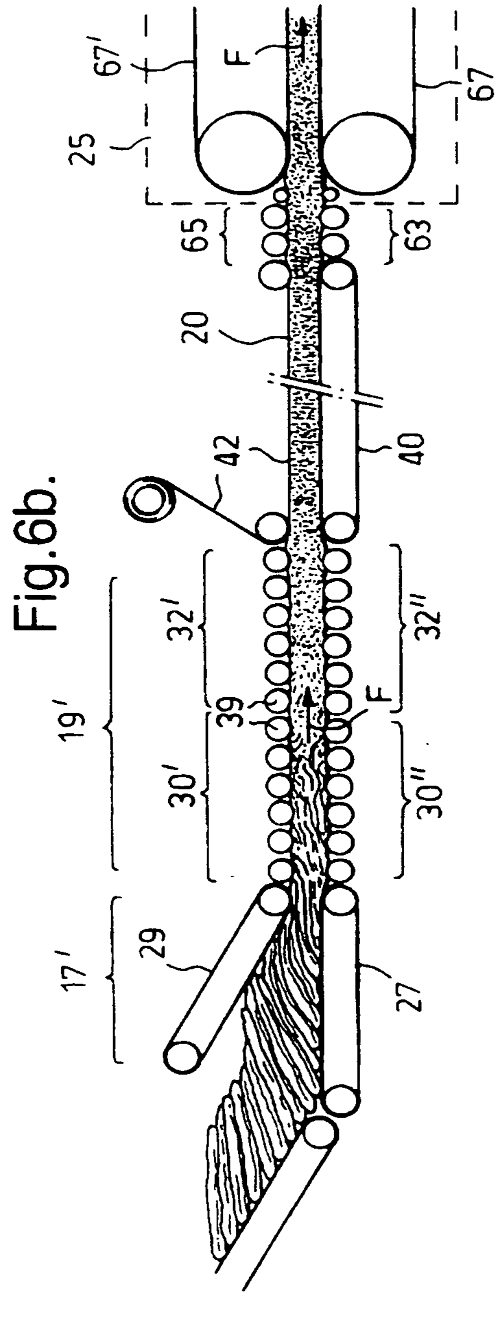
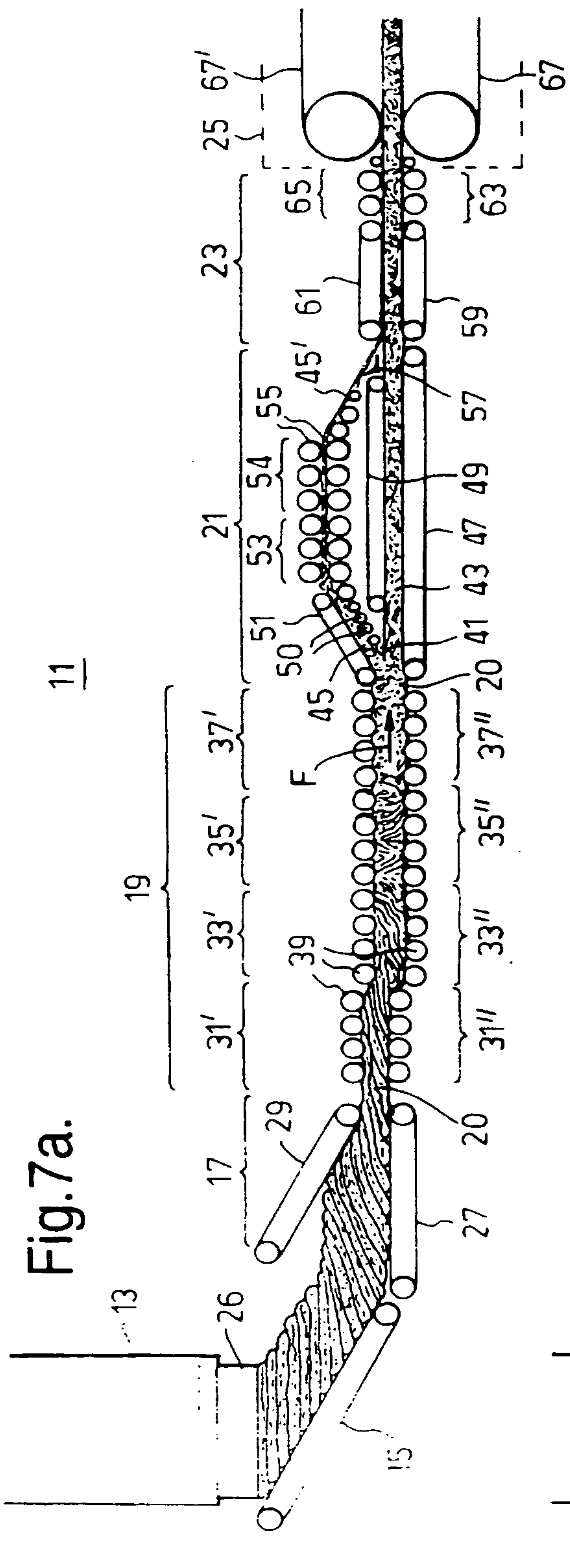

17'
29
27
19'
30'
30"
39
F
32'
32"
42
40
20
65
63
25
67'
67
F

Fig.6b.


11
19
17
29
31′
33′
35′
37′
F
39
45
50
51
53
54
55
21
45′
61
23
65
25
67′
67
63
59
57
49
47
43
41
20
37″
35″
33″
31″
20
27
26
13
15
Fig.7a.

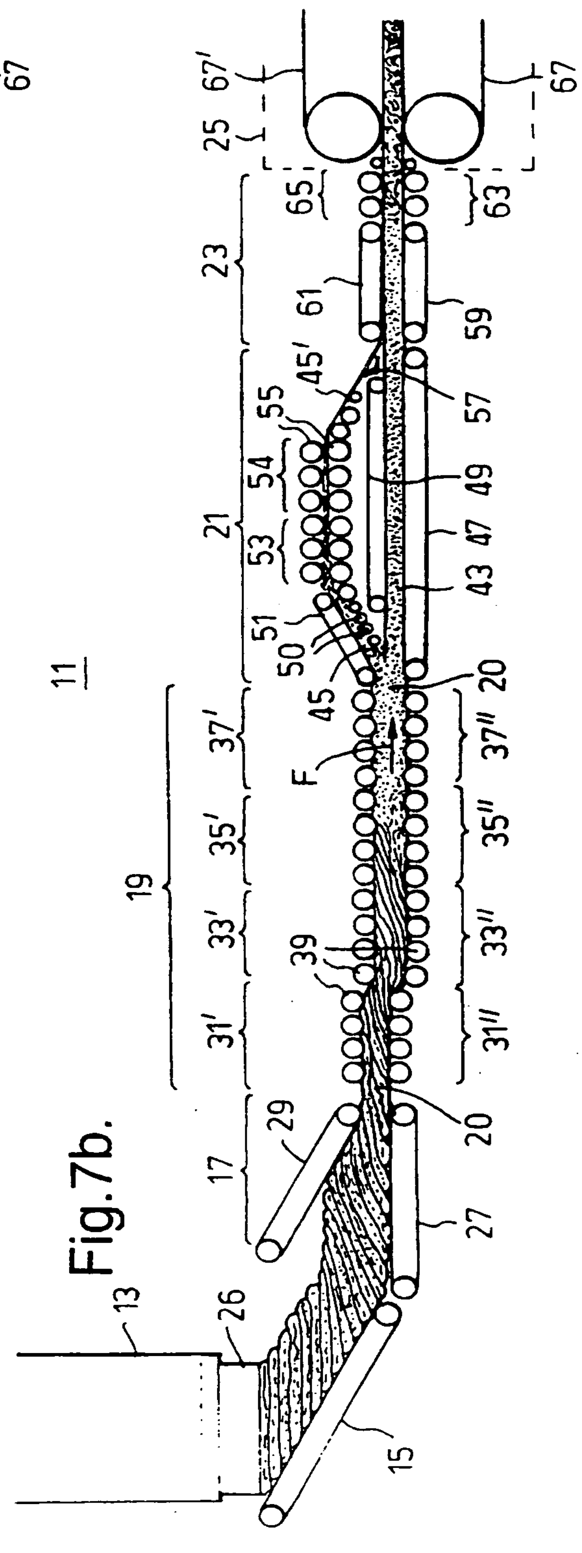

11
19
17
29
31′
33′
35′
37′
F
39
45
50
51
53
54
55
21
45′
61
23
65
25
67′
67
63
59
57
49
47
43
20
37″
35″
33″
31″
20
27
26
13
15
Fig.7b.

Fig.8.

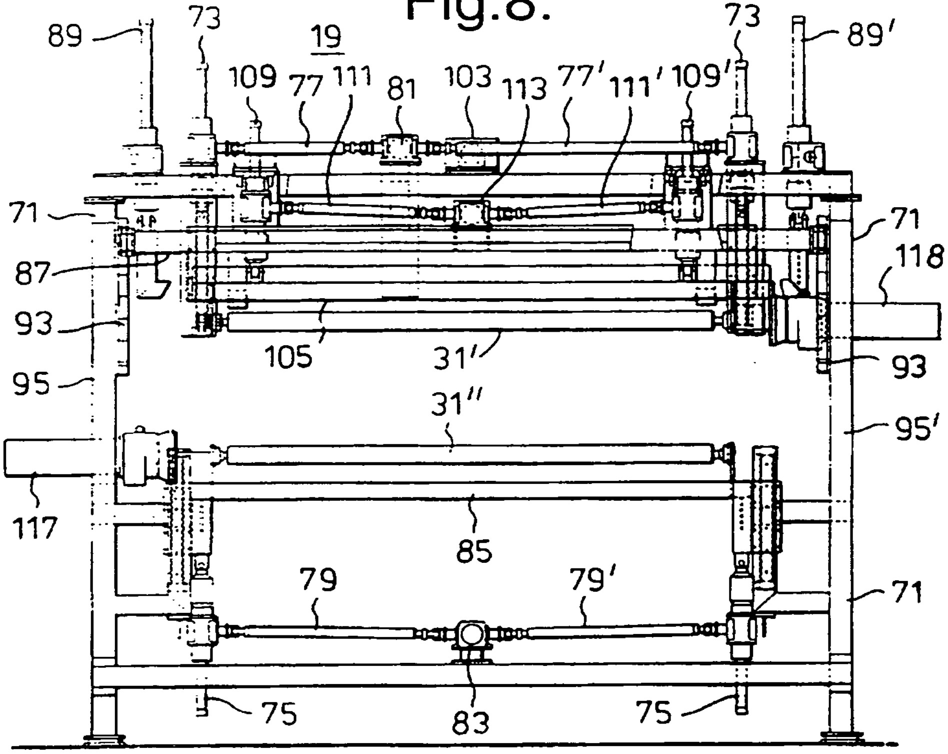

89
73
19
109
77
111
81
103
113
77'
111'
109'
73
89'
71
87
93
95
105
31'
71
118'
93
95'
31''
117
85
79
79'
71
75
83
75

Fig.10.

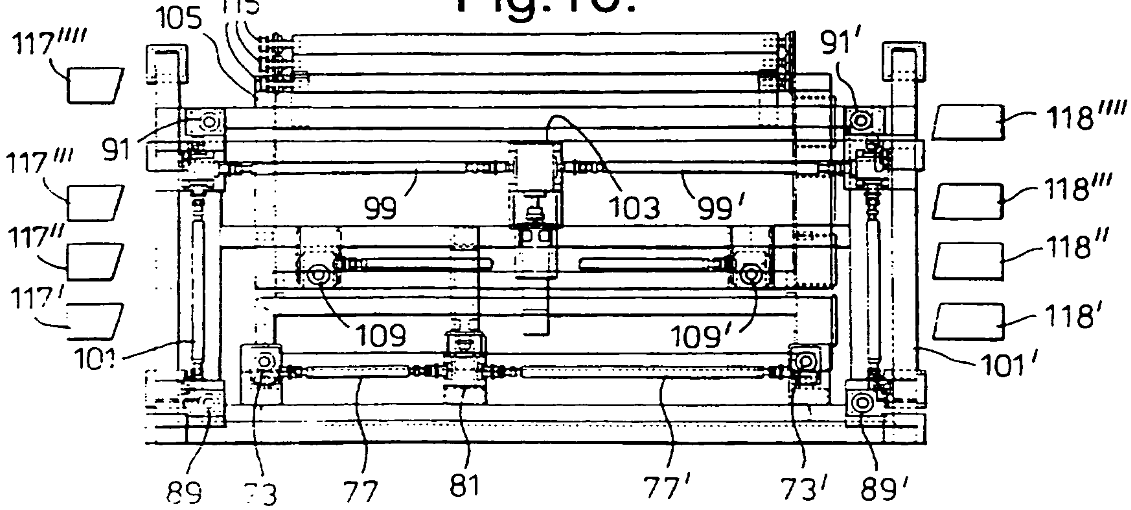
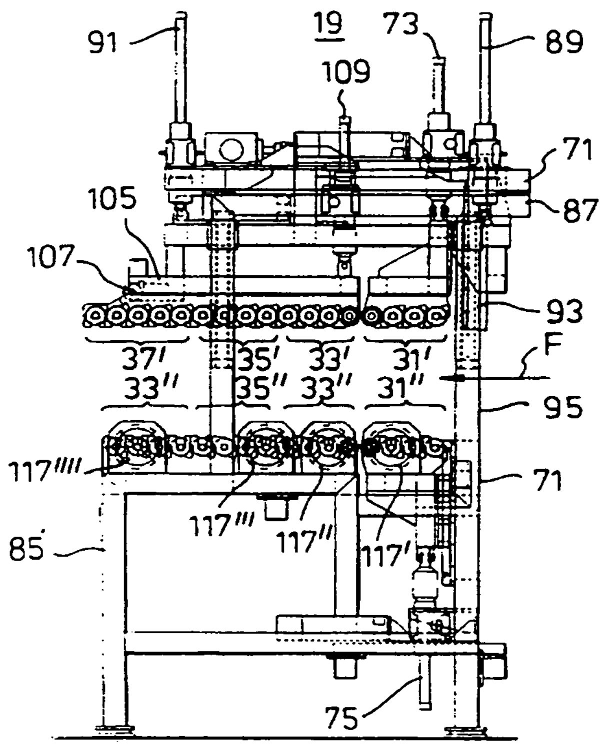

117''''
105
115
91'
118''''
117'''
91
99
103
99'
118'''
117''
118''
117'
109
109'
118'
101
101'
89
73
77
81
77'
73'
89'

Fig.9.



19
91
73
89
109
71
105
87
107
93
37'
35'
33'
31'
F
33''
35''
33''
31''
95
117''''
71
117'''
117''
117'
85
75

Fig. 11a.

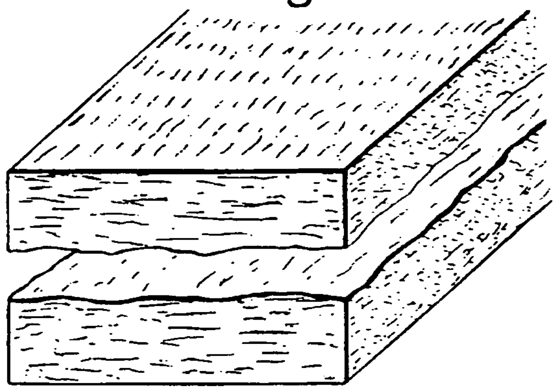


Fig. 11b.

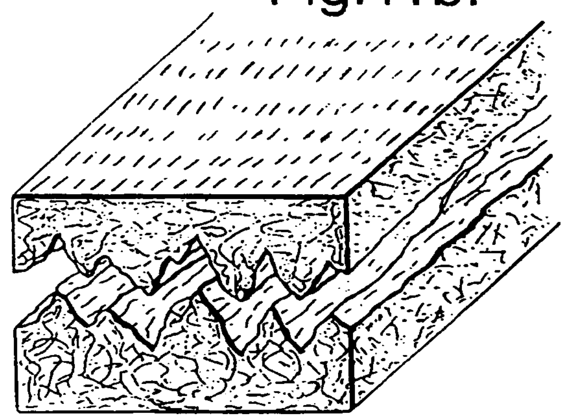


Fig. 11c.

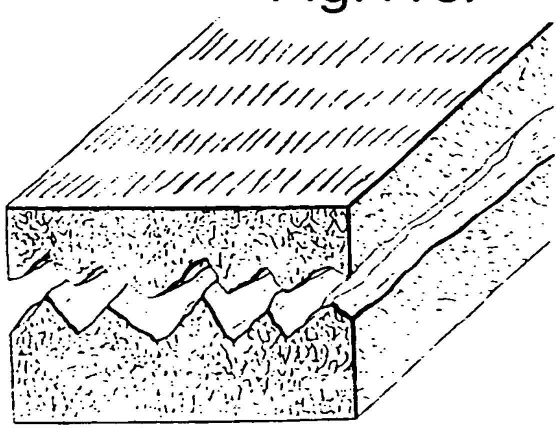


Fig.12.

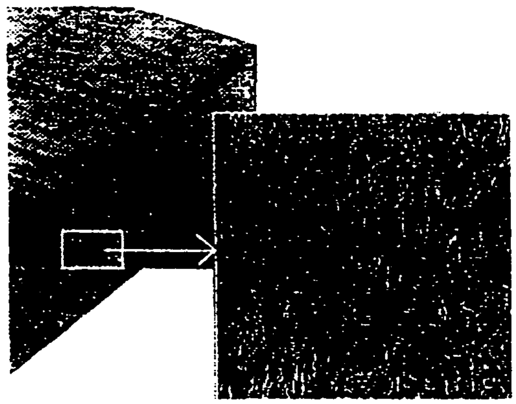


Fig.13a.

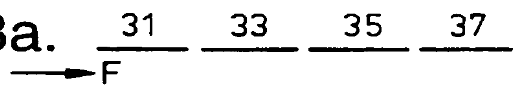


Fig.13b.

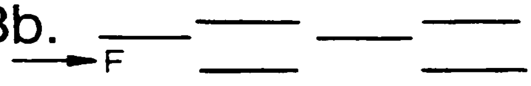


Fig.13c.

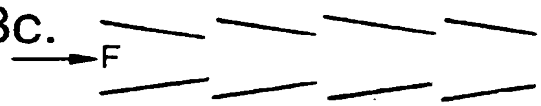


Fig.13d.

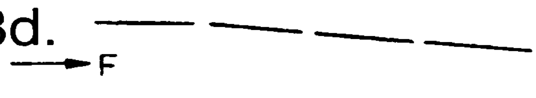
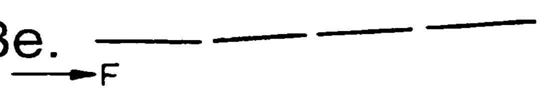


Fig.13e.



INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/EP 97/01490

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D04H1/70

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 498 276 A (RADEX HERAKLITH) 12 August 1992 see column 5, line 30 - column 6, line 43 ---	1-42
A	WO 92 13150 A (ROCKWOOL INT) 6 August 1992 see page 4, line 1, paragraph 3 - page 10, line 2, paragraph 2 ---	1-42
A	WO 88 00265 A (ROCKWOOL INT) 14 January 1988 see page 5, line 27 - page 7, line 4; example 1 ---	1-42
A	WO 92 10602 A (ROCKWOOL INT) 25 June 1992 see page 4, line 11 - page 5, line 8 --- -/--	1-42

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

2

Date of the actual completion of the international search	Date of mailing of the international search report
23 July 1997	11.08.97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Authorized officer V Beurden-Hopkins, S

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Interr ial Application No
PCT/EP 97/01490

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 94 16162 A (ROCKWOOL INT ;BRANDT KIM (DK); HOLTZE ERIK (DK)) 21 July 1994 see the whole document ---	1-42
A	EP 0 434 536 A (SAINT GOBAIN ISOVER) 26 June 1991 -----	1

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern al Application No
PCT/EP 97/01490

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0498276 A	12-08-92	DE 4135623 A	06-05-93
		AT 129755 T	15-11-95
		CS 9200234 A	14-10-92
		DE 9117005 U	02-02-95
		DE 59204158 D	07-12-95
		JP 2571171 B	16-01-97
		JP 5195402 A	03-08-93
		HR 920492 A	31-10-95
WO 9213150 A	06-08-92	AU 1166792 A	27-08-92
WO 8800265 A	14-01-88	EP 0271567 A	22-06-88
WO 9210602 A	25-06-92	AT 113087 T	15-11-94
		AU 9080591 A	08-07-92
		CA 2095532 A	08-06-92
		DE 69104730 D	24-11-94
		DE 69104730 T	04-05-95
		EP 0560878 A	22-09-93
		ES 2062884 T	16-12-94
		FI 932566 A	04-06-93
		PL 168628 B	29-03-96
		SK 56293 A	11-05-94
WO 9416162 A	21-07-94	AU 5857994 A	15-08-94
		BG 99830 A	29-03-96
		CZ 9501796 A	17-04-96
		EP 0688384 A	27-12-95
		HU 74289 A	28-11-96
		NO 952694 A	14-07-95
		PL 309895 A	13-11-95
		SK 89695 A	06-12-95
EP 0434536 A	26-06-91	CH 683272 A	15-02-94
		CH 679161 A	31-12-91
		AT 120810 T	15-04-95
		AU 642685 B	28-10-93
		AU 6810190 A	27-06-91
		CA 2032229 A	20-06-91
		DE 69018409 D	11-05-95

Form PCT/ISA/210 (patent family annex) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 97/01490

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0434536 A		DE 69018409 T	09-11-95
		ES 2073001 T	01-08-95
		JP 4316790 A	09-11-92
		NO 179081 B	22-04-96